AGU Fall Meeting, San Francisco, CA, Dec. 14-18, 2015

X-ray Amorphous Phases in Antarctica Dry Valley Soils: Insight into Aqueous Alteration Processes on Mars?

D. W. Ming, R. V. Morris, E. B. Rampe, D. C. Golden, and J. E. Quinn

The Chemistry and Mineralogy (CheMin) instrument onboard the Mars Curiosity rover has detected abundant amounts (approx. 25-30 wt. %) of X-ray amorphous materials in a windblown deposit (Rocknest) and in a sedimentary mudstone (Cumberland and John Klein) in Gale crater, Mars. On Earth, X-ray amorphous components are common in soils and sediments, but usually not as abundant as detected in Gale crater. One hypothesis for the abundant X-ray amorphous materials on Mars is limited interaction of liquid water with surface materials, kinetically inhibiting maturation to more crystalline phases.

The objective of this study was to characterize the chemistry and mineralogy of soils formed in the Antarctica Dry Valleys, one of the driest locations on Earth. Two soils were characterized from different elevations, including a low elevation, coastal, subxerous soil in Taylor Valley and a high elevation, ultraxerous soil in University Valley. A variety of techniques were used to characterize materials from each soil horizon, including Rietveld analysis of X-ray diffraction data. For Taylor Valley soil, the X-ray amorphous component ranged from about 4 wt. % in the upper horizon to as high as 15 wt. % in the lowest horizon just above the permafrost layer. Transmission electron microscopy indicated that the presence of short-range ordered (SRO) smectite was the most likely candidate for the X-ray amorphous materials in the Taylor Valley soils. The SRO smectite is likely an aqueous alteration product of mica inherited from granitic materials during glaciation of Taylor Valley. The drier University Valley soils had lower X-ray amorphous contents of about 5 wt. % in the lowest horizon. The X-ray amorphous materials in University Valley are attributed to nanoparticles of TiO_2 and possibly amorphous SiO_2.

The high abundance of X-ray amorphous materials in Taylor Valley is surprising for one of the driest places on Earth. These materials may have been physically and chemical altered during soil formation, however, the limited interaction with water and low temperatures may result in the formation of “immature” X-ray amorphous or SRO materials. Perhaps, a similar process contributes to the formation of the high content of X-ray amorphous materials detected on Mars.